

Taxonomic notes on the group of *Loepa miranda*, 1: The subgroup of *Loepa yunnana* (Lepidoptera: Saturniidae)¹

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Abstract: A review on the taxa of the subgroup around *L. yunnana* MELL, 1939 from the Himalayan and Subhimalayan region is presented. Three species are described as new: *L. kachinica* sp. n. from NE Myanmar, Kachin State, *L. bhutanensis* sp. n. from Bhutan, and *L. bretschnideri* sp. n. from NE India, Arunachal Pradesh; all male holotypes will be deposited in the collections of Zoologisches Museum der Humboldt-Universität, Berlin. All taxa of the subgroup and their corresponding male genitalia are figured.

Key words: *Loepa bhutanensis*, *Loepa bretschnideri*, *Loepa kachinica*, new species, Himalaya, high altitude species.

Taxonomische Anmerkungen zur Artengruppe von *Loepa miranda*, 1: Die Untergruppe von *Loepa yunnana* (Lepidoptera: Saturniidae)

Zusammenfassung: Es wird eine Übersicht über die Taxa der Untergruppe um *Loepa yunnana* MELL, 1939 aus dem Himalaya und südlich angrenzenden Gebirgen gegeben. Drei Arten werden als neu beschrieben: *L. kachinica* sp. n. aus Nordostmyanmar, Kachin State, *L. bhutanensis* sp. n. aus Bhutan sowie *L. bretschnideri* sp. n. aus Nordostindien, Arunachal Pradesh. Die männlichen Holotypen aller drei Arten werden in die Sammlungen des Zoologischen Museums der Humboldt-Universität, Berlin, gelangen. Alle Arten der Untergruppe und ihre männlichen Genitalstrukturen werden abgebildet.

Introduction

The genus *Loepa* MOORE, 1859 currently comprises more than 40 described species in Asia which all are of yellow colour in different shades, partly suffused with pink or orange scales. A preliminary and tentative phylogenetic grouping of the species of the genus was published by NAUMANN (1995: 82); the three species-groups of *L. oberthuri* (LEECH, 1890), *L. miranda* ATKINSON in MOORE, 1865 and *L. katinka* (WESTWOOD, 1848) were later again defined in more detail by YEN et al. (2000: 153). Within the *miranda*-group three well-defined subgroups can be recognized further due to their different genitalia morphology, form and colouration of their wings, and ecology (where known); the placement of the species into these subgroups is also supported by the results of the COI barcode, achieved from the “Canadian Centre for DNA Barcoding” (CCDB) in Guelph, Ontario.

Within the *miranda*-group, we have the following subgroups, listed in sequential arrangement of their oldest described members:

- The *miranda*-subgroup, with medium to large sized species of more or less bright yellow colour and always with completely pink to carmine forewing antemedian line, containing, e.g., *L. miranda*, *L. mirandula* YEN, NÄSSIG, NAUMANN & BRECHLIN, 2000, *L. obscuromarginata* NAUMANN, 1998, or *L. microocellata* NAUMANN & KISHIDA, 2001.
- The *damartis*-subgroup, with small to medium sized species of whitish-yellow colour, known only from China so far. Representatives are, e.g., *L. damartis* JORDAN, 1911 or *L. wlingana* YANG, 1978. This subgroup is revised in a separate paper, published simultaneously here in the same journal (NAUMANN et al. 2012).
- The third subgroup contains the species around *L. yunnana* and is dealt with here.

The subgroup of *L. yunnana* is a well-defined species-complex within the *miranda*-group in which all taxa show a fused tip of the uncus in ♂ genitalia, and, in most species, a paler yellowish ground colour, compared with other members of the genus. This subgroup is further defined by a relatively square-like, compact wing form both in ♂ and ♀ specimens, relatively small wing ocelli, two lateral rows of sclerites or two lateral sclerotised processes of the phallus (or at least an indication of these structures), partly continued on the vesica, plus large rounded dorsal tips of the valves of the ♂ genitalia, and, in general, an allopatric distribution at high to very high altitudes in the mountain slopes of the Himalaya and sub-Himalayan mountain ranges, occurring from Nepal in the west down to NE Myanmar and Yunnan in the southeast (map: Fig. 14).

During recent years legs of most populations of Palaearctic and Asian Saturniidae were sent to the “Canadian Centre for DNA Barcoding” (CCDB) in Guelph, Ontario, for sequencing and analysing using the 658 base pairs (bp) of the barcode fragment of the mitochondrial cytochrome-*c* oxydase gene, subunit I (= mtDNA COI gene) (see RATNASINGHAM & HEBERT 2007; in the web: BARCODE OF LIFE [or BOLD] 2012). DNA was extracted from the legs of dried specimens in the collections of the authors and others. Technical details of extraction and amplification and sequencing protocols can be found on the CCDB website (CCDB 2012) and are also described, e.g., in VAGLIA et al. (2008). Also within the resulting DNA

¹ The expressions “[species]-group” and, subordinate to this, “[species]-subgroup” (sometimes also “species-complex”) are used in this publication as tentative informal groupings of species which are deemed to be closely related to each other and supposedly form a monophyletic unit. However, these groupings are here not intended to be published for the purpose of zoological nomenclature (ICZN 1999: Art. 8.2.; disclaimer), and these collective group names, therefore, do not enter into the genus-group of names in zoology (ICZN 1999: Art. 10.3., 10.4.).

² 22nd contribution to the Saturniidae fauna of China (21st contribution: ROUGERIE, R., NAUMANN, S., & NÄSSIG, W. A. [2012]: Morphology and molecules reveal unexpected cryptic diversity in the enigmatic genus *Sinobirna* BRYK, 1944 (Lepidoptera: Saturniidae). – PLoS ONE, San Francisco, 7 (9): e43920 [doi:10.1371/journal.pone.0043920].)

barcode sequences the species described here and the species-subgroups and groups are well-defined (see discussion; Text-Fig. 1).

Within the species-subgroup, three species have already been described:

- *Loepa yunnana* MELL, 1939
- *Loepa tibeta* NAUMANN, 2003
- *Loepa paramiranda* BRECHLIN & KITCHING, 2010

In the present article we describe three further species from Bhutan, Arunachal Pradesh in northern India, and Kachin State in Myanmar, and provide a short review of this subgroup.

Abbreviations

BC	COI Barcode number.
BMNH	The Natural History Museum (formerly British Museum [Natural History]), London, U.K.
CAHS	Collection Armin HAUENSTEIN, Schönenberg, Germany.
CMWM	Collection Museum WITT, München, Germany, assigned to ZSM.
CSKK	Collection Steve Kohll, KAYL, Luxembourg.
CSLL	Collection Swen LÖFFLER, Lichtenstein/Sachsen, Germany.
CSNB	Collection Stefan NAUMANN, Berlin, Germany.
CWAN	collection Wolfgang A. NÄSSIG, Frankfurt am Main, now in SMFL.
GP	Genitalia dissection number.
MAKB	Museum Alexander Koenig, Bonn, Germany.
SMFL	Senckenberg-Museum, Frankfurt am Main, Germany, collection of Lepidoptera.
ZMHU	Zoologisches Museum der Humboldt-Universität, Berlin, Germany.
ZSM	Zoologische Staatssammlungen München (Munich), Germany.

Systemtic part: descriptions and diagnoses

Loepa bhutanensis sp. n.

Holotype (Figs. 1a, b dorsal, ventral view): ♂, Bhutan (Central), road Hongtsho–Lobesa, ca. 3 km E Dochu-La pass, 2800 m, 7. viii. 2005, 5:00 h at sunrise, leg. P. KAUTT & S. NAUMANN, BC SNB 0786, CSNB. The holotype will be deposited in ZMHU, Berlin, Germany.

Paratypes (in total 17 ♂♂): 7 ♂♂, same locality and date as holotype, all collected between 2:25–4:10 h, 1 ♂ with GP 1877/09 SNB, 1 ♂ with BC SNB 0785 (CSNB). 1 ♂, same data, 3:20 h, BC SNB 2643, ex CSNB (CSLL). 1 ♂, same data, ex CSNB (CAHS). 1 ♂, same data, ex CSNB (CWAN in SMFL). 6 ♂♂, Bhutan (West), Jhomolari Trek, 3 km N Shana Zampa, 3080 m, 5. viii. 2005, all collected between 2:30–5:00 h, GP 1294/05, 1878/09 SNB, BC SNB 0787 (CSNB); Fig. 2a, b. 1 ♂, same data, BC SNB 2642, ex CSNB (CSLL).

Etymology: The new taxon is named for its origin, the Kingdom of Bhutan.

Description: ♂ (Figs. 1a, b, 2a, b): Ground colour intensive bright yellow. Antennae quadripectinate, greenish ochreous with 25 segments, 13.0–13.2 mm long, longest rami 1.9 mm. Frons in ground colour, collum and pro-

thorax dark grey, legs pinkish violet, only ventral parts of femur greyish. Rest of thorax and abdomen in ground colour, the latter with a lateral and ventral row of grey hair dots on each side. Generally the forewing apex is quite rectangular which gives the species a compact form. Forewing length 53–59 mm (holotype 57 mm) from basis to apex. Both fore- and hindwings are completely of ground colour, with following markings: Costa in the proximal ca. 80% grey, antemedian line of the forewing dark carmine with an outer intensive dark grey shadow, that of the hindwing completely dark grey. Forewing ocellus ovoid, at maximum 5.2–6.9 mm diameter, with a thin proximal black margin, that of the hindwing similar, with slightly narrower black margin. The postmedian zigzag line of both fore- and hindwing intensive dark grey and of somewhat diffuse character as the underside postmedian is shining through a little proximal aside it; it is followed by a double submarginal line, the proximal one curved, the marginal one broken at the veins, on the hindwing the marginal one consisting of blue scales. Both fore- and hindwings show a marginal line of dirty yellow and white scales. On ventral side in same ground colour, the forewing antemedian line and the black proximal margin of all ocelli are missing, antemedian line of the hindwing and the postmedian line are somewhat more proximal than on dorsal side, and the two submarginal and marginal lines are of same manner as dorsal.

♂ **genitalia** (Figs. 15–17): Uncus fused to one dorsal tip, relatively broad-based. The dorsal process of the valves is widely rounded and prominent, the ventral one also relatively broad, especially if compared with the structures of *L. paramiranda*, which in general are somewhat more elongate. The internal process of the valves is almost straight with a dorsal protuberance and quite prominent. The saccus long, broad and rounded. The phallus is long, ends with a larger sclerotisation on right and a smaller one on left dorsolateral side, that on the right with numerous lateral spines. The sclerotisation on the right is connected with a broad sclerotised band to another thorn-like sclerite on the right side of the large, bulb-like vesica, and there is a separate large sclerite on left lateral position. In general, and in concordance with the large size of specimens, *L. bhutanensis* sp. n. has the largest genitalia in the subgroup.

♀: Unknown.

Loepa bretschnideri sp. n.

Holotype (Figs. 3a, b dorsal, ventral view): ♂, India, Arunachal Pradesh, Dist. Bomdila, near hillstation, 27°28.355' N, 92°41.671' E, 2800 m, 21.–23. vii. 2007, leg. BRETSCHNEIDER, GP 1882/09 SNB (Fig. 19), BC SNB 0789, CSNB. The holotype will be deposited in ZMHU, Berlin, Germany.

Paratypes (in total 52 ♂♂, 1 ♀): 30 ♂♂, same data as holotype, 1 ♂ BC SNB 2640 (CSLL). 7 ♂♂, same data as holotype, 1 ♂ BC SNB 0788 (CSNB). 2 ♂♂, same data as holotype (SMFL). 10 ♂♂, 1 ♀ (“allotype”, Figs. 5a, b dorsal, ventral view, c, antenna), India, Arunachal Pradesh, Dist. Bomdila, near hillstation, 27°28.669' N, 92°41.647' E, 2650 m, 1.–3. viii. 2006, leg. G. BRETSCHNEIDER, 1 ♀ with BC SNB 2641



Figs. 1–7: *Loepa* specimens of the *yunnana*-subgroup [always a = dorsal, b = ventral side]. **Figs. 1–2:** *Loepa bhutanensis* sp. n., ♂♂. **Fig. 1:** ♂ holotype, Bhutan (C), Dochu La Pass, ex CSNB in ZMHU. **Fig. 2:** ♂ paratype, Bhutan (W), Jhomolari Trek, CSNB. — **Figs. 3–5:** *L. bretschnideri* sp. n., India, Arunachal Pradesh, Bomdila Distr., ♂♂ + ♀. **Fig. 3:** ♂ holotype, ex CSNB in ZMHU. **Fig. 4:** ♂ paratype, CSNB. **Fig. 5:** ♀ paratype, CSLL; **Fig. 5c:** ♀ antenna. — **Figs. 6–7:** *L. kachinica* sp. n., Myanmar, Kachin State, Chudu Razi Hills. **Fig. 6:** ♂ holotype, ex CSNB in ZMHU. **Fig. 7:** ♂ paratype, CSNB. — Photos S. NAUMANN, except Fig. 5 (S. LÖFFLER). — Specimens almost to the same scale, scale in cm with 0.5 mm subdivisions (phot. S.N., grey scale), respectively 1.0 mm (phot. S.L., brown scale).

(CSLL). 3 ♂♂, same data, GP 1881/09 SNB (CSNB).

Etymology: The new taxon is named in honour of its collector, our friend Gil BRETSCHNEIDER who kindly offered us this hardly obtainable material.

Description: ♂ (Figs. 3–4): Ground colour intensive bright yellow. Antennae quadripectinate, ochreous with 27 segments, 12.4–12.6 mm long, longest rami 2.0 mm. Frons in ground colour, collum and prothorax dark grey, legs pinkish violet. Rest of thorax and abdomen in ground colour, the latter with indicated lateral and ventral rows of grey hair dots on each side. The forewing apex is a little more prominent than in the other members of the subgroup. Forewing length 53–58 mm (holotype 57 mm) from basis to apex. Both fore- and hindwings are completely of ground colour, with following markings: On dorsal side costa in the proximal ca. 60% grey or purplish grey; antemedian line of the forewing broad, carmine with dark grey shadow, that of the hindwing completely dark grey. Forewing ocellus ovoid or lenticular, small, diameter maximum 4.5–5.9 mm, with a relatively broad proximal black margin, that of the hindwing similar. The postmedian zigzag line of both fore- and hindwing dark grey and a little blurred; it is followed by a double submarginal line, the proximal one curved, the marginal one of the forewing broken at the veins, on the hindwing connected and consisting of blue scales. In general, all lines are very tiny and give the yellow ground colour a wide impression. Both fore- and hindwings show a marginal line of darker yellow and white scales. On ventral side in same ground colour, the forewing antemedian line and the black proximal margin of the forewing ocelli are missing, but those of the hindwing ocelli slightly indicated. The antemedian line of the hindwing is more proximal than on dorsal side, and the two submarginal and marginal lines are similar as on dorsal side.

♂ genitalia (Figs. 18–19): The uncus is fused to one dorsal tip, relatively broad-based, and a little shorter than in *L. paramiranda* or *L. bhutanensis* sp. n. The dorsal process of the valves is a little elongate and rounded, the ventral one relatively broad, especially if compared with the structures of the two species mentioned above, which in general are thinner. The internal process of the valves is almost straight with a rectangular dorsal protuberance, and quite prominent. The saccus long, broad and rounded. The phallus is long, ends with a sclerotisation on right dorsolateral side which is continued on the vesica with a small sclerotised band, ending in some sclerites.

♀ (Figs. 5a, b): The sole ♀ of *L. bretschnideri* sp. n. shares all characters with the ♂♂, but differs mainly in sexually dimorphic characters, such as larger, more rounded wings, higher body-weight and shorter rami of the antennae. These are bipectinate (Fig. 5c), with 26 segments, 13 mm long, with longest rami of 1.25 mm. The specimen has a forewing length of 64 mm. In difference to the ♂♂, the two submarginal lines are more intensive, and the marginal one of the forewing is blue instead of black in the lower third part. The ventral side has the same

characters as in the ♂♂. The specimen is the only known ♀ for the whole subgroup of *L. yunnana* which can safely be assigned to a certain species.

Loepa kachinica sp. n.

Holotype (Figs. 6a, b dorsal, ventral view): ♂, Myanmar (NE), Kachin State, Chudu Razi Hills, 30 miles E Kawnlangphu, ca. 2800 m, 5. viii. 2008, leg. local collector, GP 1947/09 SNB (Fig. 6a, b), BC SNB 0784, CSNB. The holotype will be deposited in ZMHU, Berlin, Germany.

Paratypes (in total 5 ♂♂): 3 ♂♂, same locality as holotype, but 4. viii. 2008, 21. vii. 2011, BC SNB 4569, and 29. viii. 2011 (CSNB, Fig. 7a, b). 2 ♂♂, same locality, 21., 29. vii. 2011 (CSKK).

Etymology: The new taxon is named for its origin, the Kachin State in northeastern Myanmar.

Description: ♂ (Figs. 6–7): Ground colour intensive light yellow. Antennae quadripectinate, greenish ochreous with 26 segments, 11.5–12.1 mm long, longest rami 2.2 mm. Frons in ground colour, collum and prothorax dark grey, legs pinkish violet. Rest of thorax and abdomen in ground colour, the latter with a lateral row of grey hair dots on each side. The forewing apex is a little bent outward and prominent. Forewing length 49–54 mm (holotype 54 mm) from basis to apex. Both fore- and hindwings are completely of ground colour, with following markings: On dorsal side costa in the proximal ca. 60% grey, antemedian line of the forewing light carmine with a black outer margin only at its costal end; that of the hindwing completely dark grey. Forewing ocellus ovoid, maximum diameter 5.8–6.0 mm, with a thin proximal black margin, that of the hindwing similar, with thinner black margin. The following lines more tiny, the postmedian zigzag line of both fore- and hindwing dark grey, followed by a double submarginal line, the proximal one curved, the marginal one mostly broken at the veins, on the hindwing the marginal one consisting of blue scales. Both fore- and hindwings show a marginal line of dark yellow and white scales. On ventral side in same ground colour, the forewing antemedian line missing, the antemedian line of the hindwing and the postmedian line are somewhat more proximally than on dorsal side, and the two submarginal and marginal lines are similar to those on dorsal side.

♂ genitalia (Fig. 20): Uncus fused to one dorsal tip, with broad base and short. Valves rounded at the dorsal margin, laterally with small indentation, which is also found more intensively in *L. yunnana*. Ventral process large, the inner process prominent, straight, and with a huge dorsal and ventral projection. The saccus is long and rounded, the phallus slender, ending with a right lateral sclerite which has a small projection on the vesica. On left dorsolateral side the vesica bears a small sclerite. In general, the genitalia are quite small compared to the other members of the subgroup, which corresponds with the slightly smaller size of specimens.

♀: Unknown.

Discussion

Results of the mtDNA barcoding

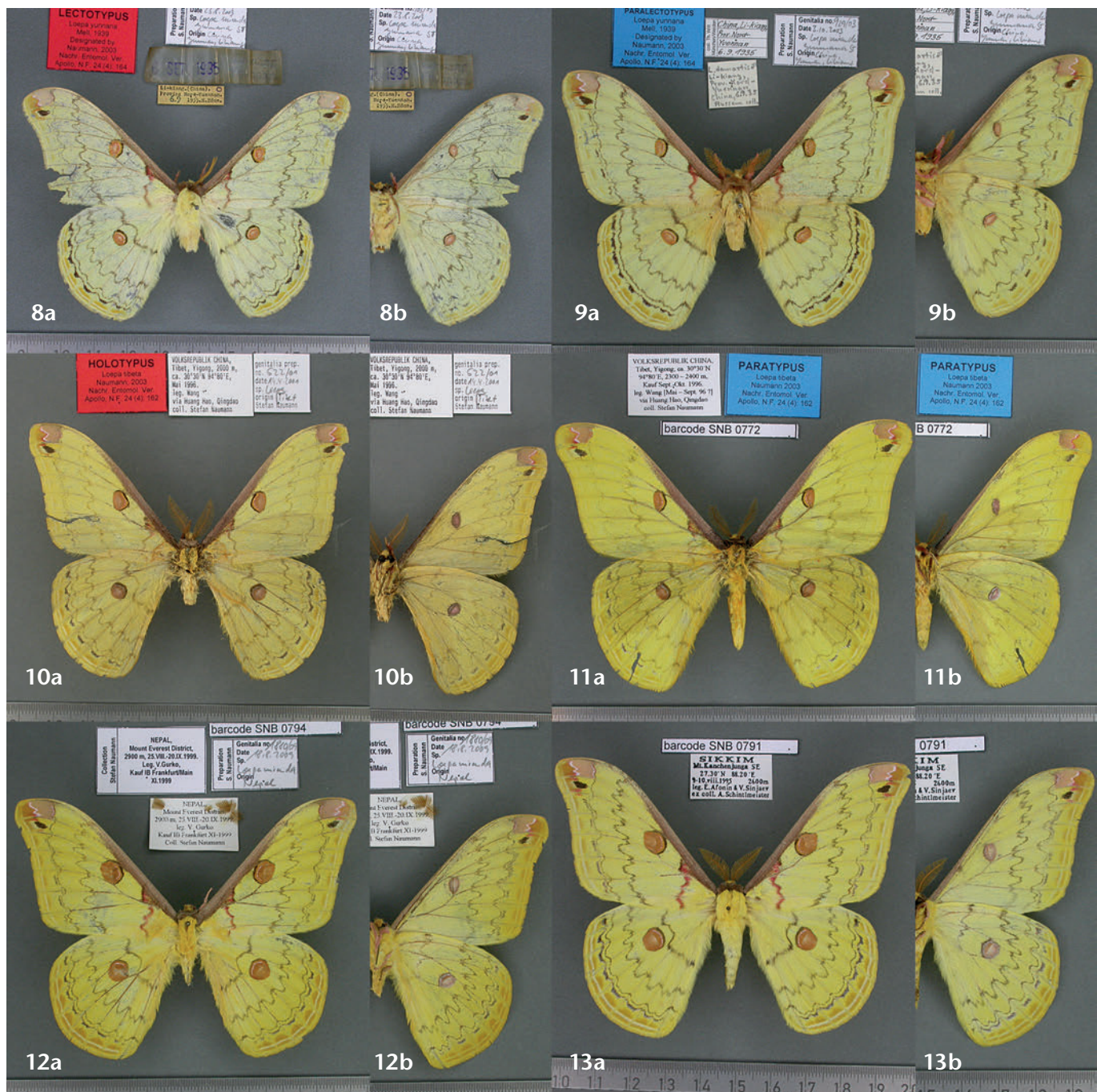
For the mtDNA analyses, we have used the sequence data of 23 specimens of the *yunnana*-subgroup and additionally (as comparison and outgroup) 2 lectotypes of other *Loepa* species (see Table 1). We have used specimens from our collections, from the collections of ZSM, and publically available data from BOLD from other collections. We have chosen as outgroup the only “old” lectotypes of the *miranda*-group whose mtDNA have so far been sequenced: the lectotypes of *Loepa miranda* and of *L. damartisi*, both deposited in BMNH. In spite of the fact that the sequence data of these two specimens is incomplete due to their age, their sequences are very important to anchor and “root” the mtDNA barcode identifications in the classical morphology-based systematics.

The sequence data were downloaded from the BOLD website and statistically analysed with MEGA5 software (TAMURA et al. 2011). We illustrate in Text-Fig. 1 some

results: in Text-Fig. 1a the Maximum Likelihood consensus tree, in 1b the linearised variant of this, and in 1c the Minimum Evolution consensus tree, always with bootstrap values added (for details, see legend). Other methods usually resulted in similar topologies. The ML and ME methods resulted in a few differences; so, for example, in the position of *L. miranda* (which is not so closely included in the *yunnana*-subgroup when using the ME method) or in the distinctness of some of the separate species, which is on average slightly better in the ME than in the ML variant. The trees shown in Figs. 1a–c are based only on 392 base pair positions, caused by the different gaps in the sequence data. However, the general topology of the trees is quite robust: when deleting all incomplete sequences before calculating the tree (and consequently also deleting the inferred outgroup), the resulting tree (then based on 658 bp) has an next to identical topology to the one figured here, respectively, but with slightly better bootstrap values for most knots.

Table 1: Data of the specimens used for the mtDNA sequence analyses. — Additional abbreviations: GBAC = GenBank Access Code; HT = holotype; LT = lectotype; PT = paratype; SL = Sequence Length (data from BOLD); — = GBAC not yet available.

Species	Sample-ID	Process-ID	GBAC	SL	Sex	Deposition	Locality of Origin
<i>Loepa yunnana</i>	SNB 774	SASNA774-09	HM383481	658[0n]bp	♂	CSNB	China, Yunnan
<i>Loepa yunnana</i>	SNB 2647	SASNC563-11	—	658[0n]bp	♂	CSLL	China, Yunnan
<i>Loepa tibeta</i> (PT)	SNB 772	SASNA772-09	GU664319	658[0n]bp	♂	CSNB	China, Tibet
<i>Loepa tibeta</i> (PT)	SNB 773	SASNA773-09	GU664321	658[0n]bp	♂	CSNB	China, Tibet
<i>Loepa kachinica</i> (HT)	SNB 784	SASNA784-09	HM432580	658[0n]bp	♂	CSNB/ZMHU	Myanmar, Kachin
<i>Loepa kachinica</i> (PT)	SNB 4569	SASNC2200-12	—	638[0n]bp	♂	CSNB	Myanmar, Kachin
<i>Loepa bretschnideri</i> (HT)	SNB 789	SASNA789-09	GU664332	658[0n]bp	♂	CSNB/ZMHU	India, Arunachal Pradesh
<i>Loepa bretschnideri</i> (PT)	SNB 788	SASNA788-09	GU664331	658[0n]bp	♂	CSNB	India, Arunachal Pradesh
<i>Loepa bretschnideri</i> (PT)	SNB 2640	SASNC556-11	—	658[1n]bp	♂	CSLL	India, Arunachal Pradesh
<i>Loepa bretschnideri</i> (PT)	SNB 2641	SASNC557-11	—	658[0n]bp	♀	CSLL	India, Arunachal Pradesh
<i>Loepa bhutanensis</i> (HT)	SNB 786	SASNA786-09	GU664330	658[0n]bp	♂	CSNB/ZMHU	Bhutan
<i>Loepa bhutanensis</i> (PT)	SNB 785	SASNA785-09	GU664328	658[0n]bp	♂	CSNB	Bhutan
<i>Loepa bhutanensis</i> (PT)	SNB 787	SASNA787-09	GU664329	658[0n]bp	♂	CSNB	Bhutan
<i>Loepa bhutanensis</i> (PT)	SNB 2642	SASNC558-11	—	658[0n]bp	♂	CSLL	Bhutan
<i>Loepa bhutanensis</i> (PT)	SNB 2643	SASNC559-11	—	658[0n]bp	♂	CSLL	Bhutan
<i>Loepa paramiranda</i> (HT)	BC-RBP-1389	SARBA729-09	—	541[0n]bp	♂	CMWM/ZSM (not located)	India, Sikkim
<i>Loepa paramiranda</i> (PT)	BC-RBP-1383	SARBA723-09	—	658[0n]bp	♂	Coll. BRECHLIN	Nepal, Janakpur Zone, Dolokha District
<i>Loepa paramiranda</i> (PT)	BC-RBP-1384	SARBA724-09	GU663544	658[0n]bp	♂	Coll. BRECHLIN	Nepal, Janakpur Zone, Dolokha District
<i>Loepa paramiranda</i> (PT)	BC-RBP-1390	SARBA730-09	—	658[0n]bp	♂	Coll. BRECHLIN	India, Sikkim
<i>Loepa paramiranda</i> (PT)	BC-RBP-1387	SARBA727-09	GU663545	658[0n]bp	♂	Coll. BRECHLIN	Nepal, Gandaki Zone, Gorkha District
<i>Loepa paramiranda</i>	SNB 794	SASNA794-09	GU664335	658[0n]bp	♂	CSNB	Nepal, Sagarmatha Zone, Solukhumbu District
<i>Loepa paramiranda</i>	SNB 2636	SASNC552-11	—	658[0n]bp	♂	CSLL	Nepal, Sagarmatha Zone, Solukhumbu District
<i>Loepa paramiranda</i> (PT)	BC-EvS 2758	SAVSE193-12	—	658[0n]bp	♂	Coll. VAN SCHAYCK	Nepal, central
For comparison as outgroup							
<i>Loepa miranda</i> (LT)	SAT-BMNH0001	SANHM001-09	—	553[89n]bp	♂	BMNH	India, [Himalaya]
<i>Loepa damartisi</i> (LT)	SAT-BMNH0002	SANHM002-09	—	630[0n]bp	♂	BMNH	[China, Sichuan]



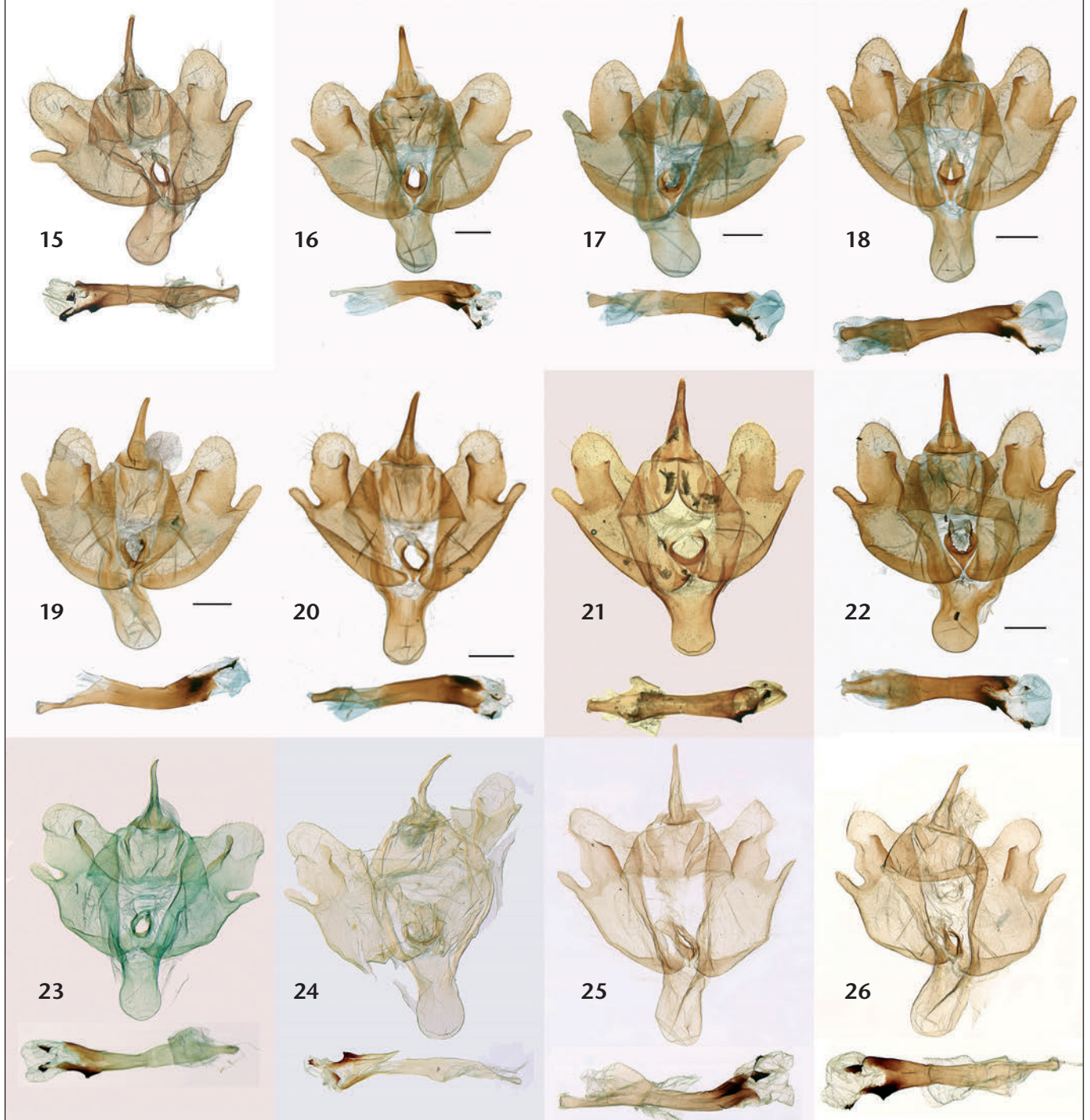
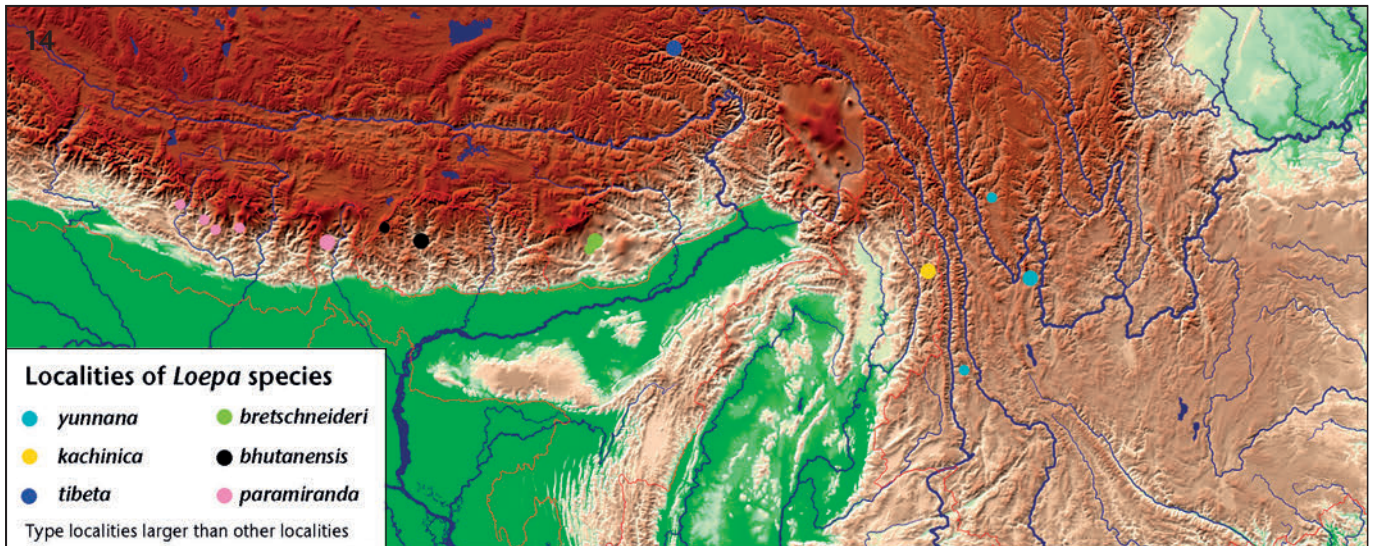
Figs. 8–13: *Loepa* specimens of the *yunnana*-subgroup [always a = dorsal, b = ventral side]. **Figs. 8–9:** *L. yunnana*, PR China, Yunnan, Lijiang. **Fig. 8:** ♂ lectotype, MAKB. **Fig. 9:** ♂ paralectotype, ex coll. Aussem in CMWM. — **Figs. 10–11:** *L. tibeta*, PR China, Tibet, Yigong. **Fig. 10:** ♂ holotype, ZMHU. **Fig. 11:** ♂ paratype, CSNB. — **Figs. 12–13:** *L. paramiranda*. **Fig. 12:** ♂, Nepal, Mt. Everest District, CSNB. **Fig. 13:** ♂, India, Sikkim, Mt. Kanchenjunga, CSNB. — Photos S. NAUMANN. — Specimens almost to the same scale, scale in cm with 0.5 mm subdivisions.

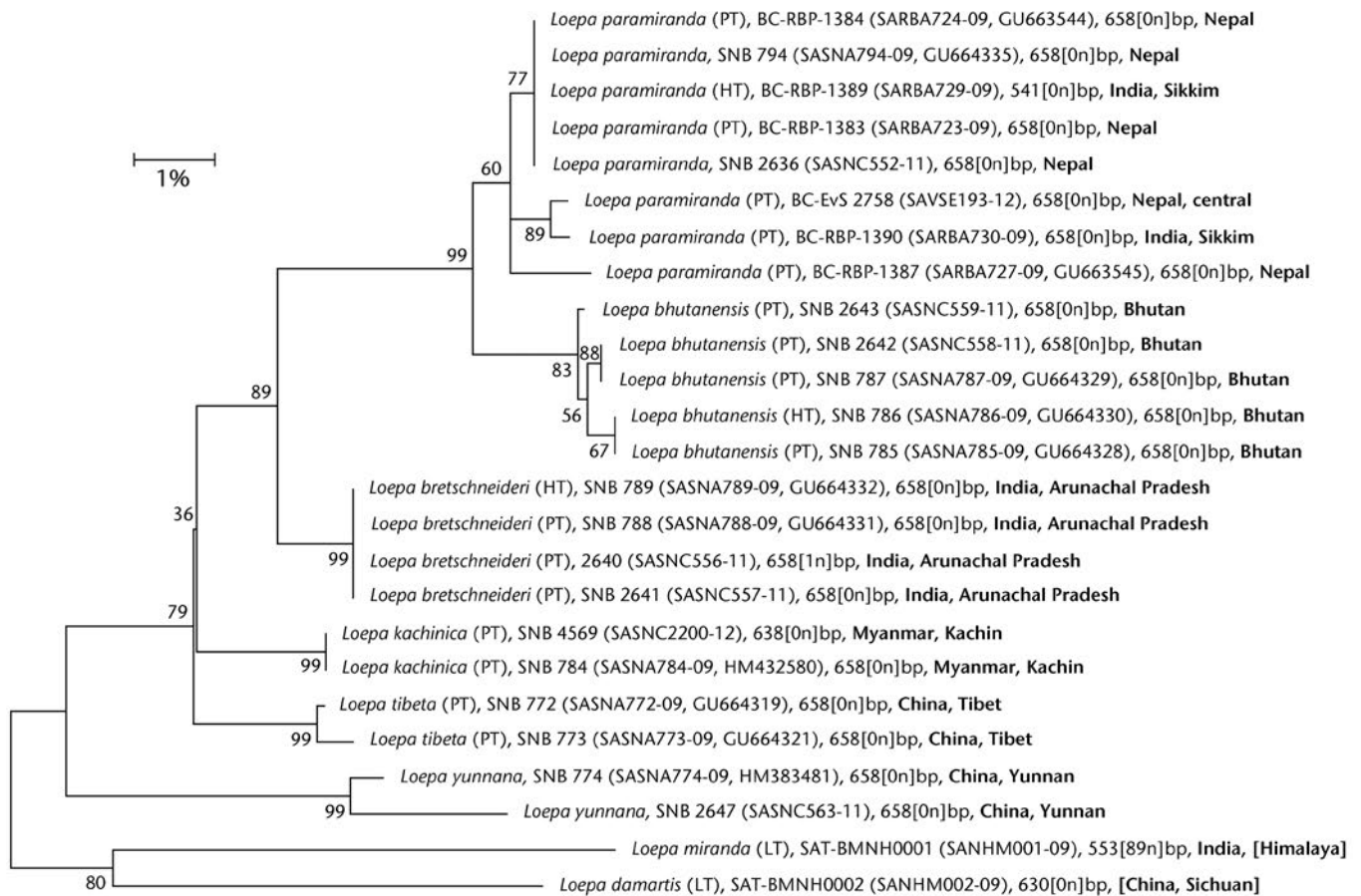
Fig. 14: Map showing the allopatric distribution of the 6 species of the subgroup of *Loepa yunnana*. Type localities in larger size of the symbols. — Map based on elevation zone colours. Map created with Map Creator 2.0 Personal Edition, © 2003–2007 www.primap.com/de/, modified and localities added [wng.]. — **Figs. 15–26:** ♂ genitalia of *Loepa* species of the *yunnana*-subgroup. **Figs. 15–17:** *Loepa bhutanensis* sp. n., Bhutan, paratypes. **Fig. 15:** GP 1294/05 SNB. **Fig. 16:** GP 1877/09 SNB. **Fig. 17:** GP 1878/09 SNB. — **Figs. 18–19:** *L. bretschnideri* sp. n., India, Arunachal Pradesh. **Fig. 18:** GP 1881/09 SNB, paratype. **Fig. 19:** GP 1882/09 SNB, holotype. — **Fig. 20:** *L. kachinica* sp. n., holotype, Myanmar, Kachin, GP 1947/09 SNB. — **Figs. 21–22:** *L. paramiranda* sp. n. **Fig. 21:** GP 0041/97 SNB, India, Sikkim. **Fig. 22:** GP 1880/09 SNB, Nepal. — **Figs. 23–24:** *L. tibeta*, China, Tibet. **Fig. 23:** GP 0522/01 SNB, holotype, ZMHU. **Fig. 24:** GP 0521/01 SNB, paratype, SNB. — **Figs. 25–26:** *L. yunnana*, China, Yunnan. **Fig. 25:** GP 0903/03 SNB, lectotype, MAKB. **Fig. 26:** GP 0929/03 SNB, paralectotype, CMWM. — Genitalia not exactly to the same scale. Scale bar (where present) = 1 mm.

We think, based on the morphology, that, in general, the result of the ML tree appears to be more likely. As the morphological differences are often small or subtle and hard to be interpreted in terms of evolutionary directions (and thus also hard to be pressed into a plausible scheme for statistical analysis), we have not constructed

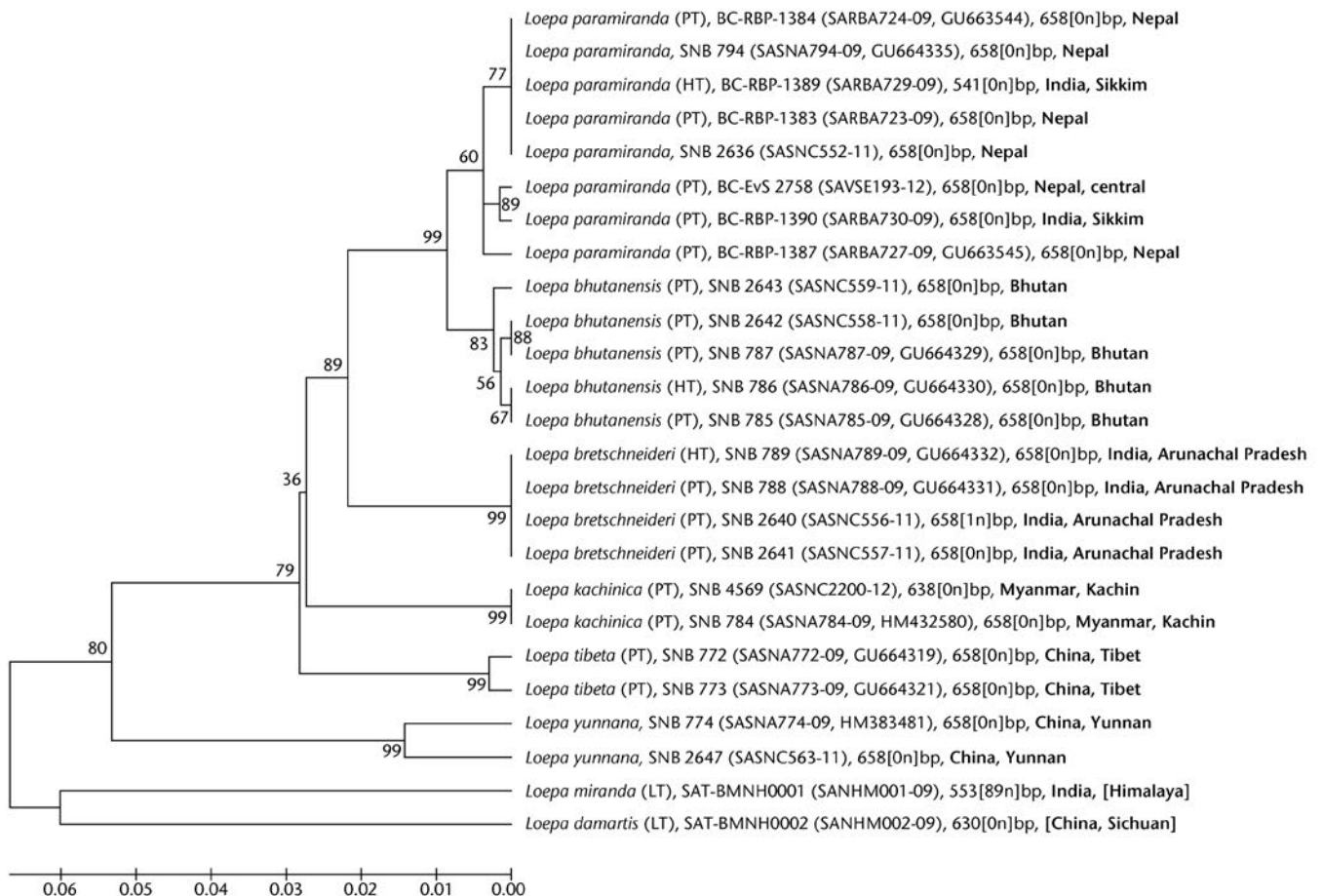
an integrative tree using both morphological and mtDNA characters for the phylogeny analysis.

The main differentiation between the species is based on morphological and biogeographical information, and the mtDNA COI barcode data generally supports this interpretation very well.

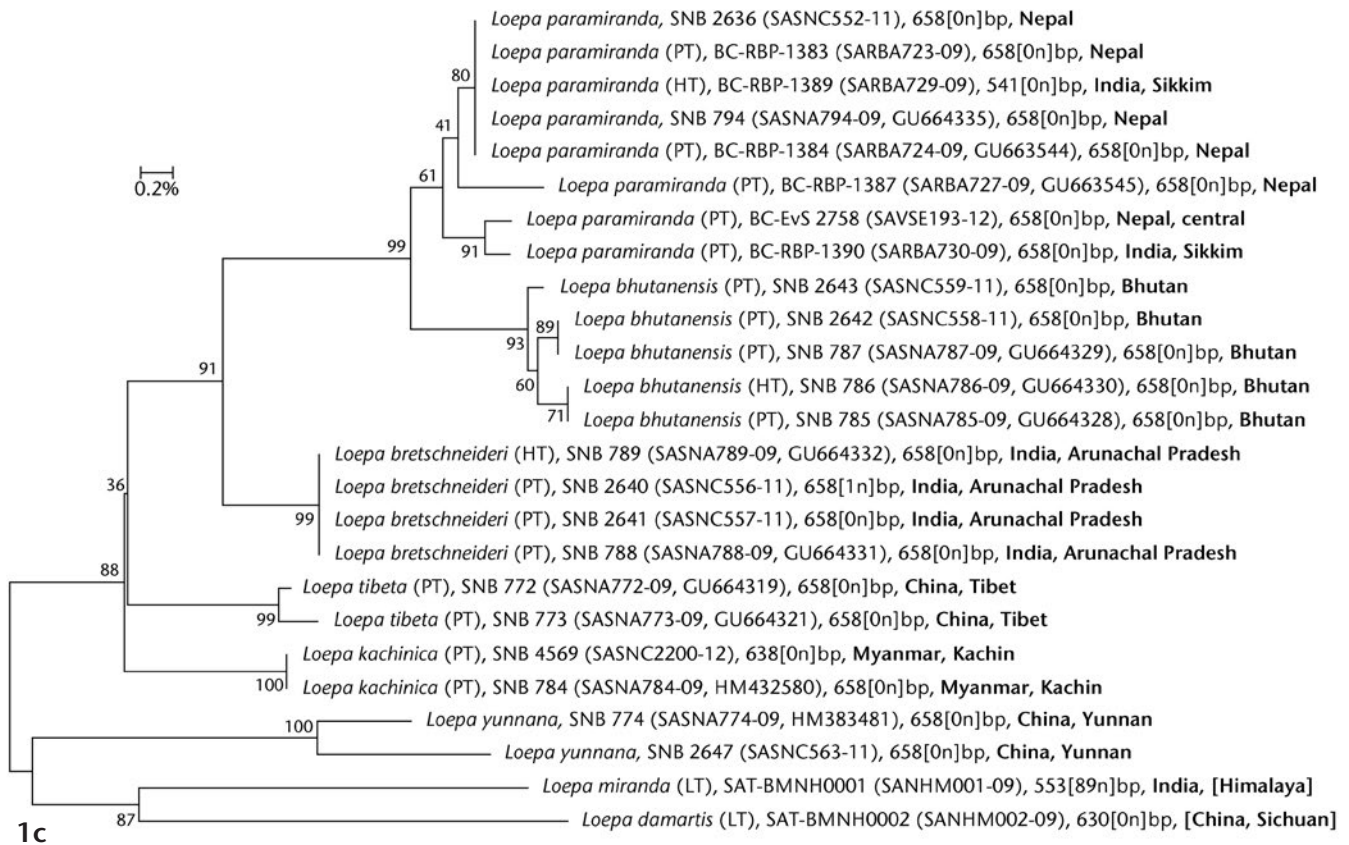




1a



1b



Text-Figs. 1a–c: Molecular phylogenetic analysis by Maximum Likelihood (ML) and Minimum Evolution (ME) methods conducted in MEGA5 (TAMURA et al. 2011). The analyses involved 25 nucleotide sequences (= specimens). Codon positions included were 1st+2nd+3rd+Noncoding. All positions containing gaps and missing data were eliminated. There were a total of 392 positions in the final dataset. The bootstrap consensus trees inferred from 1000 replicates are taken to represent the evolutionary history of the taxa analyzed (FELSENSTEIN 1985). Branches corresponding to partitions reproduced in less than 50% bootstrap replicates are collapsed. The percentage of replicate trees in which the associated taxa clustered together in the bootstrap test are shown next to the branches. — **Text-Fig. 1a:** The evolutionary history was inferred by using the **Maximum Likelihood** method based on the Data specific model (NEI & KUMAR 2000). Initial tree(s) for the heuristic search were obtained automatically as follows. When the number of common sites was < 100 or less than one fourth of the total number of sites, the maximum parsimony method was used; otherwise BIONJ method with MCL distance matrix was used. A discrete Gamma distribution was used to model evolutionary rate differences among sites (5 categories [+G, parameter = 0.4294]). The rate variation model allowed for some sites to be evolutionarily invariable (+I, 64.9946% sites). The tree is drawn to scale, with branch lengths measured in the number of substitutions per site. — **Text-Fig. 1b:** The same **ML-consensus tree** as before, but linearized, so that the percentage of difference in the sequences becomes clearer visible. — **Text-Fig. 1c:** The evolutionary history was inferred using the **Minimum Evolution** method (RZHETSKY & NEI 1992). The tree is drawn to scale, with branch lengths in the same units as those of the evolutionary distances used to infer the phylogenetic tree. The evolutionary distances were computed using the Maximum Composite Likelihood method (TAMURA et al. 2004) and are in the units of the number of base substitutions per site. The rate variation among sites was modeled with a gamma distribution (shape parameter = 3). The differences in the composition bias among sequences were considered in evolutionary comparisons (TAMURA & KUMAR 2002). The ME tree was searched using the Close-Neighbor-Interchange (CNI) algorithm (NEI & KUMAR 2000) at a search level of 0. The Neighbor-joining algorithm (SAITOU & NEI 1987) was used to generate the initial tree.

Definitions and diagnoses of the species

Within the subgroup of species around *L. yunnana* we found 6 different species which all are confined to restricted areas at high altitudes of the Himalaya and its neighbouring mountain chains to the Southeast, 3 of which are described as new in the present publication. From the biogeography it may be expected that further taxa of this group remain to be discovered. Most specimens with actual data were collected in the last decade of July and the first half of August.

So far the following species can be recognized:

Loepa yunnana MELL, 1939

This taxon was described as *L. miranda yunnana* by MELL and later placed into synonymy of *L. miranda* by OWADA & WANG (1992: 154), without mentioning any reasons

for that act, and probably without having seen any type material of the taxon. YEN et al. (2000: 161) revised the status after checking some syntypes, and raised *yunnana* to specific rank due to external (wing shape, pattern, and colouration) and genitalia morphology, compared to *L. miranda*. A syntype of this taxon plus its genitalia were figured there for the first time (YEN et al. 2000: figs. 4A, B, 12). NAUMANN (2003: 164, fig. 4 ♂, fig. 10 genitalia) designated a lectotype for *L. yunnana* from the collection of MAKB which was figured in the same paper and gave an overview about the remainings of MELL's type series; so far only 7 specimens of 20 syntypes mentioned in the original description could be located; these are held in MAKB and CMWM, now in ZSM. The lectotype from MAKB (Figs. 8a, b) and a paralectotype from CMWM (Figs. 9a, b) plus ♂ genitalia (Figs. 25–26) are figured here again for comparison.

L. yunnana was never mentioned in any Chinese publication on Saturniidae (WANG 1988, XUE & WANG 1989, ZHANG 1986, ZHU & WANG 1982, 1983, 1993, 1996). The colour figure of a ♀ (under the misidentification “*L. anthera* JORDAN, 1911”) from Tibet, Lebu, 2840 m, in XUE & WANG (1989: pl. IX, fig. 5) might belong to *L. yunnana*, but could also be the unknown ♀ of *L. tibeta* (see also notes on this figure in NAUMANN 2003: 165).

Diagnosis: The oldest taxon of the subgroup is of light yellow ground colour, similar to *L. kachinica* sp. n., and has a light carmine antemedian line of the forewing with only small costal black marginal shadow. It is the only species in the subgroup where the bluish outer submarginal line of the hindwing is completely continuous, and in most specimens it is also very prominent; the hindwing inner submarginal line is less wavy than in any other species of the subgroup. *L. yunnana* is known from a few localities in Central and West Yunnan only.

Note. There exists another taxon in China which superficially looks very similar to *L. yunnana* but can be separated by its ♂ genitalia structures, details in ornamentation and elongated forewing form, and its separate status is also confirmed by the COI barcode. It occurs in the southern parts of Sichuan and in the northeastern tip of Yunnan, as far as known currently. Due to its close relationship to *L. damartisi* JORDAN, 1911, it is dealt with in a separate paper (NAUMANN et al. 2012: 101).

Data for *L. yunnana* studied (all China, Yunnan): Likiang, ix./x. 1935 (lectotype: 6. x. 1935), leg. H. HÖNE, GP 903/03, 929/03, 930/03 SNB (MAKB, CMWM in ZSM). NW, Dali Bai autonom. Pref., Yunlong Co., Fengshuining Mts., 13 km N Caojian, 25° 46' N, 99° 6' E, 2460 m, 25. vii.–8. viii. 1999, leg. R. BRECHLIN, BC SNB 0774 (CSNB). Bailakou Pass env., 63 km NW Zhongdian, 3500 m, 1. viii. 2010, leg. S. MURZIN, BC SNB 2647 (CSLL).

Loepa tibeta NAUMANN, 2003

L. tibeta was described from 5 specimens, all from Yigong, Tibet, which is a national park area located around Pome, Nyingchi, Tibet, at 30°5' N, 95°4' E. So far the species is known only from its type series. The ♂ paratype mentioned by NAUMANN (2003: 162) from a figure in ZHANG (1986: pl. 7, fig. 59) could not be located in the collections of Academia Sinica yet, its deposition is currently unknown. There are no confirmed further records of this taxon in other recent Chinese literature (WANG 1988, XUE & WANG 1989, ZHU & WANG 1982, 1983, 1993, 1996). Possibly the ♀ (under the misidentification “*L. anthera* JORDAN, 1911”) from Tibet, Lebu, 2840 m, figured in XUE & WANG (1989: pl. IX, fig. 5) might belong to *L. tibeta*, but more likely it is the unknown ♀ of *L. yunnana*. The holotype in ZMHU (Figs. 10a, b) and a paratype in CSNB (Figs. 11a, b) plus the genitalia (Figs. 23–24) are figured for comparison.

Diagnosis: *L. tibeta* specimens are those with least ornamentation in the subgroup, the forewing antemedian line is reduced to a thin greyish line which ends towards the costal margin with a proximal carmine patch. The ocelli are small and formed lenticular to ovoid. ♂ genitalia

are somewhat unique with their large, widened dorsal process of the valves with lateral indentions and bent internal process, plus the right and left lateral sclerites on the end of the phallus and on the vesica.

Data for *L. tibeta* specimens studied: PR China, Tibet, Yigong, ca. 30°30' N, 94°80' E [sic], 2000 and 2300–2400 m, v.–ix. 1996, leg. WANG, GP 521/01, 522/01 SNB, BC SNB 0772, 0773 (ZMHU, CSNB).

Loepa kachinica sp. n., described above

Diagnosis: *L. kachinica* sp. n. is the smallest member of the subgroup, looks more delicate, and has much reduced markings. The ground colour is a light creamy yellow, the antemedian line is of light carmine colour, and the ocelli are ovoid and relatively small. In ♂ genitalia there is a typical lateral indentation of the dorsal process of the valves which is shared only with *L. yunnana* (there in a different, less prominent way) and *L. tibeta* (much more prominent), the inner process has a typical dorsal and ventral protuberance, and the sclerites of the phallus have a unique structure. In general, corresponding with the smaller size of the specimens, also the ♂ genitalia are of smallest size in the subgroup.

L. kachinica sp. n. is obviously confined to mountainous areas in the almost inaccessible parts of Kachin in NE Myanmar. Due to the hard accessibility of the area specimens are very rare in collections, and nothing can be said about a possibly wider range of that species. In nearby Yunnan a different species, *L. yunnana*, occurs, which is possibly also the closest relative (not when considering the barcode analysis). Both species and the other members of the subgroup appear to be confined in their habitats and separated from their relatives by even higher mountain chains in between.

Loepa paramiranda BRECHLIN & KITCHING, 2010

This species was described from a series of 30 ♂♂ specimens; it was separated from *L. miranda*, which occurs in part syntopical and synchronous, by its more rounded forewings and less elongate forewing apex, in general slightly smaller size, and differences in the valves of the ♂ genitalia (BRECHLIN & KITCHING 2010: 12). The holotype could not be located in CMWM or ZSM, although it was stated in the original description that it is deposited there. We figure a topotypic ♂ from Sikkim (Figs. 13a, b) and a further ♂ from Nepal (Figs. 12a, b); genitalia see Figs. 21–22. The ♂ figured by ALLEN (1993, pl. 44) as *L. katinka* is in fact the only specimen of *L. paramiranda* which was figured prior to its description; the notes by ALLEN fit exactly with the characters of that species.

Diagnosis: *L. paramiranda* has quite compact, rounded forewings; it is characterized by a relatively broad pinkish purple antemedian line of the forewing and relatively large, rounded ocelli on all wings. For further details and differences to its closest relative, *L. bhutanensis* sp. n., see under diagnosis of that taxon. *L. paramiranda* is known only from Sikkim, India, and from Eastern Nepal so far.

Data for *L. paramiranda* specimens studied: India, Sikkim, Mt. Kanchenjunga SE, 27°30' N, 88°20' E, 2225 m, 11.–14. viii. 1995,

leg. AFONIN & SINJAEV, BC SNB 4600, 4601 (CMWM in ZSM). Almost same locality, 27°30' N, 88°20' E, 2600 m, 9.–10. VIII. 1995, leg. AFONIN & SINJAEV, GP 41/97 SNB, BC SNB 0791 (CSNB). — Nepal, Mt. Everest Distr., 2900 m, 25. VIII.–20. IX. 1999, leg. V. GURKO, GP 1880/09 SNB, BC SNB 0794, 2636 (CSLL, CSNB, CWAN in SMFL). Dolakha Prov., Ganesh Himal Prov. and Jiri, different localities mentioned in the original description.

Loepa bhutanensis sp. n., described above

Diagnosis: *L. bhutanensis* sp. n. is well defined in morphology by the combination of its intensive bright yellow colouration, large size, the antemedian line consisting of dark carmine and grey shadow, and the diffuse postmedian line. Especially in comparison to its closest relative, *L. paramiranda*, known from Nepal and Sikkim, the following differences can be observed (in spite of the only small differences in COI barcode): The latter taxon has a pinkish purple antemedian line in the forewing, larger and more rounded ocelli on all wings, a more distinctive postmedian line, and is generally of little smaller size. Also ♂ genitalia of *L. bhutanensis* sp. n. are a little larger than those of *L. paramiranda*, which has more elongate valve processes, less indicated sclerotisations on the phallus with narrower or no connection to the sclerites on the vesica.

L. bhutanensis sp. n. is known so far only from high elevation localities in West and Central Bhutan, where it probably is somehow separated by higher mountain chains from the other members occurring in the West or East of its distribution.

Loepa bretschneideri sp. n., described above

Diagnosis: *L. bretschneideri* sp. n. is somewhat unique in the subgroup, defined by combination of its large size, light but bright yellow ground colour, small ocelli, reduced ornamentation of the postmedian and submarginal lines, the dark and broad forewing antemedian line, and the sclerotisation only on the right side on the phallus tip and vesica. It easily can be separated from its probably closest relative, *L. tibeta*, by the still larger wing ocelli with broad proximal black margin, larger size in general, and in genitalia by the unique sclerotisation. Also by the results of the COI barcode the separate standing of *L. bretschneideri* sp. n. becomes easily visible.

L. bretschneideri sp. n. is known only from the southern Himalayan slopes in the northern parts of Arunachal Pradesh, India, near to the Tibetan border.

Earlier records of the taxa in literature

None of the species of the *yunnana*-subgroup were mentioned under a misidentification in the following earlier literature on Saturniidae from India (e.g., MOORE 1859, 1865, HORSFIELD & MOORE 1860, COTES & SWINHOE 1887, SWINHOE 1892, 1894, HAMPSON 1893, ARORA & GUPTA 1979), from Nepal (HARUTA 1992, SMITH 2001; but see under *L. paramiranda* about a note in ALLEN 1993), from Bhutan (DIERL 1975, BRECHLIN 2009) nor from Myanmar (BRYK 1944, NAUMANN et al. 2008). Aside of two figures

(under misidentified names, see under *L. yunnana* and *L. tibeta* above) in ZHANG (1986) and XUE & WANG (1989) none of the taxa were ever dealt with also in Chinese literature on Saturniidae as cited already above.

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